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MATHEMATICS.—*Note on multiple algebra: The reduction of real dyadics and the classification of real homogeneous strains.* EDWIN BIDWELL WILSON, Massachusetts Institute of Technology. (Communicated by Arthur L. Day.)

1. About ten years ago I printed an account of some parts of Gibbs's course of lectures on multiple algebra.[1] In the classification, or reduction to a canonical form, which was there established for dyadics no attention was paid to distinctions between real and imaginary. I had in mind at that time to give the extension of Gibbs's work in Vector Analysis[2] needed to obtain the reduction of real dyadics to type forms, but did not publish my results. I desire now to show how the algebraic methods used by Gibbs to find the general classification lend themselves immediately to the further subdivision relative to reality.

The sort of dyadic under consideration is (p. 11):[3]

$$\Phi = \alpha \mid \alpha^0 + \beta \mid \beta^0 + \ldots,$$

where the antecedents α, β, . . . are ordinary vectors and the consequents α^0, β^0, . . . are $(n-1)$-dimensional vectors in n-dimensional space. (The vertical bars serve as separators and

[1] WILSON, EDWIN B. *On the theory of double products and strains in hyperspace.* Trans. Conn. Acad. Arts Sci., **14**: 1–57. 1908.

[2] GIBBS-WILSON. Vector Analysis, pp. 356–367.

[3] The page numbers in the text refer to the memoir cited in Note 1. I here use an upper zero instead of a dash over a letter to represent an $(n-1)$-vector.

have no connection with Grassmann's Ergänzung.) The only kind of multiplication used in the work is the (progressive or regressive, single or multiple) combinatory product. That means that we work with the affine, not with the metric, group of linear transformations with one point fixed, i. e., with homogeneous strains.

2. The essential steps in the reduction of a dyadic are these:

(*a*) As there are only n^2 independent dyads, any dyadic must satisfy a polynomial equation, with numerical coefficients, of degree not exceeding n^2. Hence any dyadic satisfies an equation

$$\Lambda(\Phi) = \Phi^m + c_1\Phi^{m-1} + \ldots + c_{m-1}\Phi + c_m I = 0$$

of *lowest* degree, I being the idemfactor. This equation is unique for if there were two of like lowest degree, their difference would be of lower degree (pp. 15–16.)

(*b*) As any dyadic is homologous (commutative in multiplication, p. 14) with its powers and with I, the equation of lowest degree may be factored in the form:

$$\Lambda(\Phi) = (\Phi - aI)^p(\Phi - bI)^q(\Phi - cI)^r \ldots = 0$$

identical with that obtained in factoring the ordinary polynomial

$$\begin{aligned}\Lambda(x) &= x^m + c_1 x^{m-1} + \ldots + c_{m-1}x + c_m \\ &= (x-a)^p(x-b)^q(x-c)^r \ldots = 0.\end{aligned}$$

(*c*) If we set (p. 26)

$$\Phi - aI = \Psi,\ \Phi - bI = \Psi + (a-b)I,\ \Phi - cI = \Psi + (a-c)I, \ldots$$

and if we divide (by the ordinary algorism of long division, which is applicable here) the expression

$$(\Phi - bI)^q(\Phi - cI)^r \ldots = AI + B\Psi + \ldots + H\Psi^{q+r+\cdots}$$

into I, we have the result

$$\frac{I}{AI + B\Psi + \ldots + H\Psi^{m-p}} = \frac{1}{A}I + B'\Psi + \ldots + G'\Psi^{p-1} + \frac{\Psi^p P(\Psi)}{AI + B\Psi + \ldots + H\Psi^{m-p}}$$

where P is a polynomial of degree $m - p - 1$. Next, let (p. 27)

$$I_a = (AI + B\Psi + \ldots + H\Psi^{m-p})\left(\frac{1}{A}I + B'\Psi + \ldots + G'\Psi^{p-1}\right)$$
$$= I - \Psi^p P(\Psi)$$

with similar expressions for I_b, I_c . . . . corresponding to each of the roots b, c, ... The dyadics I_a, I_b, ... are partial idemfactors, their squares are equal to themselves, they are independent, the product of two having different subscripts vanishes ($I_a I_b = 0$), and the sum of all is the idemfactor I.

(*d*) The dyadic Φ may be written as a sum of terms (p. 28)

$$\Phi = \Phi I = \Phi\ (I_a + I_b + \ldots)$$
$$= \Phi_a + \Phi_b + \Phi_c + \ldots$$

where the product of any two vanishes ($\Phi_a \Phi_b = 0$). The dyadics

$$Z_a = \Phi_a - aI_a, \ldots,$$

are nilpotent, i. e., $Z_a^p = 0$. The series of powers (p. 29)

$$Z_a, Z_a^2, \ldots, Z_a^{p-1}, Z_a^p = 0$$

have increasing nullities, but the change of nullity between two succeeding powers never increases.

The reduction of Φ has thus been simplified to that of nilpotent dyadics Z. Beginning with Z_a^{p-1} we may work back through descending powers to Z_a and hence to Φ_a. We thus find the familiar result that, when expressed in matrical or quadrate form, Φ consists of a set of terms along the main diagonal, with at most some terms in the next parallel partial diagonal (called shearing terms, p. 31).

3. What additional information is obtainable if the dyadic is real? The steps in the proof may be traced one at a time.

(*a'*) The equation of least degree must be real since it is unique—a complex equation is equivalent to two.

(*b'*) The complex roots of $\Lambda(x) = 0$ occur in conjugate pairs of the same multiplicity. Hence if a and b are conjugate imaginaries, p and q are equal.

(*c'*) If a and b are conjugate imaginaries, so are $\Phi - aI$ and $\Phi - bI$, and hence so must be I_a and I_b, for they are obtained by similar real operations applied to conjugate imaginaries.

(d') If a and b are conjugate, so are Φ_a and Φ_b, and Z_a and Z_b. If Z_a is reduced to a certain standard form, one form of the conjugate imaginary dyadic Z_b will be that in which each vector (antecedent or consequent) and each scalar in Z_a is replaced by its conjugate value. Hence the types of Z_a and Z_b or of Φ_a and Φ_b must be identical relative to the distribution of shearing terms.

The results thus obtained allow us to set up canonical forms for real dyadics which have imaginary latent roots. As the antecedents α, β, . . . of the dyads occur in conjugate imaginary pairs, the consequents which form the reciprocal set α', β', . . . (p. 8) also occur in conjugate imaginary pairs (since they are obtained by multiplication and division).

If there is a pair of simple roots, the corresponding terms in the reduced form of the dyadic are $a\,\alpha\,|\,\alpha' + b\,\beta\,|\,\beta'$ where

$$\alpha'\,\alpha = \beta'\,\beta = 1, \qquad \alpha'\,\beta = \beta'\,\alpha = 0,$$

owing to the relations between reciprocal sets. We may write

$$\begin{aligned} a &= a_1 + a_2 i & b &= a_1 - a_2 i \\ \alpha &= \alpha_1 + \alpha_2 i & \beta &= \alpha_1 - \alpha_2 i \\ \alpha' &= \alpha_1^0 - \alpha_2^0 i & \beta' &= \alpha_1^0 + \alpha_2^0 i \end{aligned}$$

with the reciprocal relations yielding

$$\begin{aligned} \alpha_1^0\,\alpha_1 + \alpha_2^0\,\alpha_2 &= 1 & \alpha_1^0\,\alpha_2 - \alpha_2^0\,\alpha_1 &= 0 \\ \alpha_1^0\,\alpha_1 - \alpha_2^0\,\alpha_2 &= 0 & \alpha_1^0\,\alpha_2 + \alpha_2^0\,\alpha_1 &= 0 \end{aligned}$$

when real and imaginary parts are separated. Hence

$$\alpha_1^0\,\alpha_2 = \alpha_2^0\,\alpha_1 = 0 \qquad \alpha_1^0\,\alpha_1 = \alpha_2^0\,\alpha_2 = \tfrac{1}{2}$$

If we set $\alpha_1' = 2\alpha_1^0$, $\alpha_2' = 2\alpha_2^0$, the sets α, β, . . . and α', β', . . . may be replaced by α_1, α_2, . . . and α_1', α_2', . . .

On multiplying, the terms $a\,\alpha\,|\,\alpha' + b\,\beta\,|\,\beta'$ give

$$\begin{aligned} &a_1\alpha_1\,|\,\alpha_1' + a_2\alpha_1\,|\,\alpha_2' \\ &a_2\alpha_2\,|\,\alpha'_1 + a_1\alpha_2\,|\,\alpha_2' \end{aligned} \quad \text{or} \quad \begin{aligned} &s\,\cos\theta\;\alpha_1\,|\,\alpha_1' + s\,\sin\theta\;\alpha_1\,|\,\alpha_2' \\ &-s\,\sin\theta\;\alpha_2\,|\,\alpha_1' + s\,\cos\theta\;\alpha_2\,|\,\alpha_2' \end{aligned}$$

if $a = se^{\theta i}$. This is precisely of the Gibbs cyclotonic form, as might have been anticipated. The linear transformation or strain is a combination of stretching with elliptical rotation.[4]

[4] An elliptical rotation of angle q is a projection of an ordinary rotation of angle q. See Vector Analysis, p. 349.

The proof here given differs radically, however, from that given by Gibbs[5] for the simple three dimensional case; it applies, moreover, to any pair of conjugate latent roots, simple or not, when shearing terms are absent.

In case there is a double complex root with shearing, the terms in the reduced complex form of the dyadic are

$$a\alpha\,|\,\alpha' + a\gamma\,|\,\gamma' + \alpha\,|\,\gamma' + b\beta\,|\,\beta' + b\delta\,|\,\delta' + \beta\,|\,\delta'$$

Multiplication shows that the corresponding real form is, in matrical notation, as follows:

$$\begin{matrix} s\cos\theta & s\sin\theta & 1 & 0 \\ -s\sin\theta & s\cos\theta & 0 & 1 \\ 0 & 0 & s\cos\theta & s\sin\theta \\ 0 & 0 & -s\sin\theta & s\cos\theta \end{matrix}$$

The extension to the case of multiple roots with various shearing terms is clear. In the matrix there are two-rowed determinants strung along the main diagonal, all alike; and parallel to the main diagonal there are strung along with any distribution (depending on the distribution of the original shearing terms) two-rowed determinants, all alike, and of the special form shown above; all other places are filled with zeros.

The transformation in the case of multiply complex roots with shearing might be called a cyclotonic shear. It consists of a stretch and of an elliptic rotation in a series of planes P_1, P_2, . . . , P_{k-1}, P_k, the angles of rotation and the factors of stretching being the same for all, combined with a shift of the points in P_{k+1} parallel to P_k for at least some values of h. The amount of the shift is typical of the shear. For instance, in the case of a triple complex root with double shearing the vector

$$\rho = x\alpha_1 + y\alpha_2 + z\gamma_1 + w\gamma_2 + u\epsilon_1 + v\epsilon_2$$

suffers, in addition to the stretch and elliptical rotation, the shift

$$+ z\alpha_1 + w\alpha_2 + u\gamma_1 + v\gamma_2.$$

[5] GIBBS-WILSON. Vector Analysis, p. 360.

MINERALOGY.—*Halloysite from Colorado.*[1] ESPER S. LARSEN, Geological Survey, and EDGAR T. WHERRY, National Museum.

In the upper workings of the fluorite mine at Wagon Wheel Gap, Colorado, two amorphous hydrous aluminium silicates have been recognized which agree more or less closely with halloysite as defined by Dana but differ from one another considerably in water content. One has essentially the composition of kaolinite, but is for the most part sensibly isotropic and has the index of refraction 1.557. It occurs in rather large amount as

TABLE 1

ANALYSES AND THEORETICAL COMPOSITION OF HALLOYSITE

	1	2	3	4
Al_2O_3	35.75	35.41	35.58	34.66
Fe_2O_3	tr.	tr.	tr.	.....
CaO	0.80	0.73	0.77	.....
MgO	tr.	tr.	tr.	.....
K_2O	tr.	tr.	tr.	.....
Na_2O	0.10	0.09	0.10	.....
SiO_2	39.95	40.22	40.09	40.90
H_2O below 100°	8.55	8.66	10.73	12.22
H_2O 100°–400°	2.15	2.10		
H_2O above 400°	12.85	12.91	12.88	12.22
Total	100.15	100.12	100.15	100.00

1 and 2. Analyses of halloysite.
3. Average of 1 and 2.
4. Theoretical for $Al_2O_3 . 2SiO_2 . 2H_2O . 2Aq.$

TABLE 2

LOSS OF WATER BY HALLOYSITE[2]

TEMP. °C	PER CENT LOSS	TOTAL
20	Started	
30	6.40	
40	0.90	
50	0.75	8.60
60	0.50	
100	0.05	
110	0.00	
150	0.10	
200	0.40	2.10
300	0.60	
400	1.00	
Ign.	12.90	12.90

the matrix in which the mineral creedite is imbedded and has been called "isotropic kaolinite."[3] The other contains more

[1] Published with the permission of the Director of the U. S. Geological Survey and of the Secretary of the Smithsonian Institution.

[2] LOWENSTEIN (Zeit. Anorg. Chem., **63**: 88–101. 1909), found that halloysite from Laurium, Greece, lost 21.4 per cent H_2O at 110°–130° or over 97 per cent H_2SO_4, and 6.2 per cent above 130°, but most halloysites cited by Dana behave like the one here described.

[3] LARSEN, ESPER S., and WELLS, ROGER C. *Some minerals from the fluorite-barite vein near Wagon Wheel Gap, Colordo.* Proc. Nat. Acad. Sci., **2**: 360. 1916.

water, and is less abundant, forming a matrix for nodules of gearksutite. It is white and opaline to dull in appearance, and has a hardness of about 2. Under the microscope it is isotropic and has a variable index of refraction, averaging about 1.470 ± 0.010 when first examined, but increasing to 1.542 after standing for six months in a loosely stoppered bottle in a warm room.[4]

Analysis (by E. T. W.) yielded the results shown in Table 1.

TABLE 3

CHANGE IN OPTICAL PROPERTIES OF HALLOYSITE WITH LOSS OF WATER

HISTORY OF MINERAL	TOTAL H_2O. (APPROX.)	OPTICAL CHARACTER	n.
	per cent		
As first examined, two months after collecting	25	Isotropic	1.470±0.010
After standing six months in a loosely stoppered bottle	20	Isotropic	1.542±0.005
Heated for four hours to 65°C. This has the composition and index of the "isotropic kaolinite," which is evidently only a halloysite low in H_2O	15	Isotropic	1.555±0.003
Ignited powder, after standing one month	0	Partly isotropic but partly birefracting due to strain; clouded	1.541±0.003
Powder ignited, quickly cooled, and immersed in index medium (organic liquid of known n)	0	In large part isotropic but some fragments have birefringence of 0.01, with large axial angle	1.535±0.005

[4] Two halloysites represented by analyses A and B of U. S. Geol. Survey Bull. 591: 341, were examined microscopically for comparison. That represented by analysis A, from Horse Cove, Hart County, Kentucky, is pale pinkish in color and opaline in appearance. Much of it is weakly birefracting and large areas extinguish much as a unit but with a wavy effect, probably due to strain. The index of refraction is about 1.549 ± 0.003. The halloysite represented by analysis B, from Edwards County, Texas, is chalky in appearance, largely isotropic, and has an index of refraction of 1.556 ± 0.003, but contains admixed a considerable amount of birefracting kaolinite. However, to what extent their indexes have changed since analysis is unknown.

The water determinations (Table 2) were made by heating coarse powder in a covered platinum dish. The powder not used was kept for three months in a small vial in a balance case in which the air was dried with sulfuric acid, and was then found to have lost spontaneously 5 per cent of water. Obviously, the water in halloysite is in part only mechanically held. This part is given off very readily, and the resulting partially dehydrated material has a composition near that of kaolinite. The formula should therefore probably be written $Al_2O_3.2SiO_2.2H_2O.Aq$.

The effects of the loss of water on the optical properties are shown in Table 3.

The close approach of this and many other analyses of halloysite to the composition $Al_2O_3.2SiO_2.2H_2O.Aq$, combined with the results of optical examination given above, indicates that the material called halloysite is the amorphous mineral corresponding to crystalline kaolinite, holding through capillarity or adsorption more or less excess water.

ORNITHOLOGY.—*Diagnosis of a new laniine family of Passeriformes.* HARRY C. OBERHOLSER, Bureau of Biological Survey.

The peculiar shrike-like Madagascar genus *Tylas* has commonly been considered a member of the family Pycnonotidae. This disposition has probably been due to its nuchal hairs, and to the character of its external nares, which in general resemble those of the genus *Otocompsa*.

As Mr. W. P. Pycraft has recently shown,[1] this genus is really not closely allied to the Pycnonotidae. Neither is it a member of the Prionopidae, to which family Mr. Pycraft has proposed to refer it, apparently for want of a more satisfactory place. While in some osteological respects it resembles the Prionopidae, it has also resemblances to the Muscicapidae, and, on the whole, presents a very curious combination of characters, a condition reflected in the difficulty authors have had in referring it to the proper family.

That it does not belong in the Prionopidae is at once evident

[1] Proc. Zool. Soc. Lond., 1907, p. 376.

from the structure of the narial capsule alone, which in the latter group is fully ossified as in the Laniidae, leaving no external nasal fossa. Since there is no other family to which the genus *Tylas* is properly referable, it becomes necessary to provide one for its accommodation, as follows:

Tylidae, fam. nov.

Family characters.—Bill relatively slender and thrush-like, the culmen rather sharply ridged, the gonys rounded and but slightly and gradually ascending, the culmen straight for its basal half, gently decurved terminally; mental apex opposite anterior end of nostril; maxilla conspicuously hooked at tip, the commissural edge notched subterminally; nostril rather small, oval, non-operculate, exposed, and situated in the anterior end of nasal fossa; nasal capsule not ossified; feathering of forehead covering only basal portion of nasal fossae; narial bristles rather weak, but reaching to middle of bill; rictal bristles well developed; head entirely feathered; nuchal hairs present but short; tail moderately long, making up somewhat less than half the total length of the bird, square or slightly emarginate, and composed of moderately broad, stiffish feathers; wings much longer than tail but much rounded, the first (outermost) primary spurius, but more than half as long as the next, and neither secondaries nor tertials lengthened; feet and legs of moderate size and length; tarsi scutellate; femur pneumatic; ectepicondylar process of humerus much reduced.

The genus *Tylas* Hartlaub, comprising the following five species, constitutes this monotypic family: *Tylas eduardi* Hartlaub; *Tylas alfredi* Sharpe; *Tylas albigularis* Hartlaub; *Tylas fulviventris* Sharpe; *Tylas strophiatus* Stejneger.

ANTHROPOLOGY.—*Remarks on terms of relationship.*[1] TRUMAN MICHELSON, Bureau of American Ethnology.

Some years ago Kroeber[2] undertook to show that terms of relationship are linguistic and psychological phenomena. Re-

[1] Published with the permission of the Secretary of the Smithsonian Institution.

[2] Journ. Roy. Anthrop. Inst. Gr. Brit. and Irel., **39**: 77–84. 1909.

cently Rivers[3] has attempted to overthrow this view, holding that they are sociological phenomena, and consequently that it is entirely possible to infer marriage customs and social organization from these terms. Lowie[4] to a certain extent followed Rivers but has not followed the latter's survival-theories, nor is it likely that many American ethnologists will do so.[5] The present writer[6] developed Kroeber's linguistic thesis from a different angle, and also made a new point, namely, that terms of relationship are likewise disseminative phenomena. Specific data from Algonquian tribes were given to establish these facts. Lowie,[7] some months later, but quite independently, arrived also at this second theoretic position but extended the principle more broadly than the present writer had done. It is not without interest to note that we both assume that Iroquoian and Siouan influence has played a part in Algonquian terms of relationship. Sapir[8] briefly touches upon the methodological considerations and concludes that thoroughly satisfactory results can not be secured without linguistic analysis of kinship terms; that existing nomenclature may be retained in the face of sociological developments requiring its modification; that the factors governing kinship nomenclature are very complicated. Goldenweiser,[9] in his review of Rivers' *History of Melanesian Society*, says, "A set of terms must always remain a feature of language and as such it is subject to those influences which control linguistic changes as well as to the peculiar spirit of a particular language or linguistic stock." The present writer[10] has shown what extraordinary types of marriage we should have to assume existed formerly among the Piegans, were we to believe that marriage customs

[3] Kinship and Social Organization, 1914. The History of Melanesian Society, 1914.

[4] Proc. Nat. Acad. Sci., **1**: 346–349. 1915. Amer. Anthrop. n. ser., **17**: 223–239, 329–340, 588–591. 1915.

[5] WEBSTER (Amer. Anthrop., n. ser., **17**: 175–177. 1915) is an isolated exception.

[6] Proc. Nat. Acad. Sci., **2**: 297. May, 1916.

[7] Holmes Anniversary Volume, 293. December, 1916.

[8] Amer. Anthrop., n. ser., **18**: 327, footnote 1. 1916.

[9] Science, n. ser., **44**: 826. 1916.

[10] Holmes Anniversary Volume, 333. 1916.

might safely be inferred from terms of relationship; whereas such marriages are fundamentally repugnant to the Piegans, and their terms of relationship are new, not old. This is, of course, a concrete example of one of Sapir's points. Recently Swanton[11] quite similarly brings forward data from Creek and Chickasaw which prove the unsoundness of such inferences.

The above has been cited to show that American ethnologists generally have taken a united stand against Rivers' one-sided attitude. I reopen the case because none of us has given absolute proof that kinship terms are borrowed. In another place[12] I have tried to prove that Cree has borrowed certain terms from Ojibwa; and somewhat similarly that Peoria has been influenced by Sauk, etc. I think the reasoning given there is sound, and as near absolute proof as we can expect to have in the case of prehistoric linguistic borrowing; yet it is not absolute in so far as we have no Cree nor Ojibwa records transmitted to us historically, extending over several centuries, showing absolutely that such borrowing took place. The same is true regarding Peoria. English is a good language to draw on for illustrative material to prove such a point, for it has been transmitted historically for several centuries. Every Indo-European philologist knows that *sister* is Scandinavian in origin, and that *cousin*, *niece*, *nephew*, *aunt*, and *uncle* are Romance. Furthermore all our terms of *-in-law* are directly or indirectly due to the latter's influence; *grand-father* and *grand-mother* are Romance in the first member of their compounds. Similarly Albanian *frat* "brother" is Romance in origin and is not a native word, as is shown by the phonetics. In the same way Hungarian *barát* "brother" is borrowed from Slavic, a case of borrowing across linguistic stocks. [Ojibwa *nimpāpa*, *nimāmā* (Fort William) are other illustrations of kinship terms borrowed across linguistic stocks.] These facts, long known, are brought forward simply because they seem to have escaped the attention of ethnologists. Delbrück[13] was well aware of the fact that Indo-European terms of relationship

[11] Amer. Anthrop. n. ser., **18**: 463. 1916 [1917].

[12] Proc. Nat. Acad. Sci., **2**: 297. 1916.

[13] Die Verwandtschaftsnamen. Leipzig. 1889. Also in Abh. phil.-hist. Klasse sächs. Ges. Wiss., **11**: 379. 1889.

are linguistic phenomena. Several terms that correspond phonetically occur in so many Indo-European languages that it is evident they belonged to the Indo-European parent language. The social organization of the peoples speaking the historical languages had nothing to do with it, as is shown by their diverse social organization. Nor can it be said that such German compounds as *Schwieger-mutter*, *Schwieger-vater*, *Schwieger-tochter* have replaced the Old High German words by reason of a change in social organization. Similarly, the fact that the Slavic word for "father" (Old Bulgarian *otъcъ*) has a different termination than Greek ἄττα, Gothic *atta*, is of linguistic significance, not sociological. These data support my contenion referred to previously.[4]

Let us return once more to Rivers' position. On looking over the tables given at the end of volume 1 of Rivers' *History of Melanesian Society*, I am convinced that after all, he may have just as much a linguistic and disseminative problem as a sociological one. For example, the social organization of Mota, Banks Islands, and Eddystone, Solomon Islands, is entirely different; nevertheless the terms for *father*, *elder brother*, and *younger brother* are evidently the same. Furthermore, the distribution of slightly varying forms of the words *tama*, *tina* (*father* and *mother* respectively) even across linguistic stocks, points in the same direction. As I am not a specialist in Melanesian and Polynesian linguistics, I regret that I can not thresh this out to the end, and can only indicate a problem for others to solve.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*Contributions to the geology and paleontology of San Juan County, New Mexico. 2. Vertebrate faunas of the Ojo Alamo, Kirtland, and Fruitland formations.* CHARLES W. GILMORE. U. S. Geological Survey Professional Paper 98–Q. Pp. 279–308, with 8 plates and 13 figures. 1916.

The known vertebrate fauna of the dinosaur-bearing beds in the San Juan basin in northern New Mexico consists of a considerable number of genera and species. The dinosaur-bearing deposits are subdivided into three formations—the uppermost, or Ojo Alamo, the Kirtland, and the Fruitland. No mammal, bird, or amphibian remains have yet been recorded from these formations. The dinosaurs were apparently the predominating vertebrates of these times, and they afford the best basis for a comparison with forms found elsewhere. The vertebrate remains from the Ojo Alamo, Kirtland, and Fruitland formations show beyond all question that they pertain to a fauna or faunas distinctly older than that of the Lance, and such evidence as there is contributes to the support of the contention that the Ojo Alamo sandstone is synchronous with the Judith River and Belly River formations as found in areas to the north. R. W. S.

GEOLOGY.—*Contributions to the geology and paleontology of San Juan County, New Mexico. 3. Nonmarine cretaceous invertebrates of the San Juan basin.* T. W. STANTON. U. S. Geological Survey Professional Paper 98–R. Pp. 309–326, with 5 plates and figures. 1916.

Overlying the Pictured Cliffs sandstone with apparent conformity in the San Juan basin and underlying the Puerco formation is a group of nonmarine sediments, coal bearing in the lower part, which in many previous reports have been referred more or less doubtfully to the Laramie formation. The rocks occupying this interval are fully described

and a considerable area of them is mapped in a stratigraphic paper by C. M. Bauer, who recognizes in them three formations, the Fruitland formation containing all the coal beds at the base, the Kirtland shale in the middle, and the Ojo Alamo sandstone at the top. The invertebrates, which form the subject of the present paper, nearly all come from the Fruitland formation.

The list of species shows that the nonmarine invertebrates of the Fruitland formation include both a fresh-water fauna and a brackish-water fauna. The fresh-water fauna is especially notable for the greatly varied development of the genus Unio and for the abundance and considerable variety of the gastropods. The invertebrate evidence as a whole favors the assignment of the Fruitland formation to an epoch considerably later than Mesaverde and Judith River, and possibly somewhat earlier than Lance. The Fruitland can hardly be older than Fox Hills, and the sequence from the base of the Fruitland up to the top of the Ojo Alamo, which is conformable, may include the equivalents of everything from the Fox Hills to the Lance inclusive.

R. W. S.

GEOLOGY.—*Contributions to the geology and paleontology of San Juan County, New Mexico. 4. Flora of the Fruitland and Kirtland formations.* F. H. KNOWLTON. U. S. Geological Survey Professional Paper 98–S. Pp. 327–353, with 8 plates and figures. 1916.

The object of the present study is to ascertain the bearing of the fossil plants on the age of the series of coal-bearing and related rocks in San Juan basin, New Mexico. A brief historical setting for the geologic facts is given. The material on which the present report is based comprises 20 collections, of which 15 are from the Fruitland formation, 3 from the Kirtland shale, and only 1 from the Ojo Alamo sandstone. The bulk of the material comes from the lower or coal-bearing portion of the section, and much of this is preserved on a red baked shale, indicating proximity to coal. Of the 40 forms making up the known flora of the Fruitland and Kirtland formations, 16 have been found in other areas, and the list of these forms brings out the fact that no less than 15 are known to occur in the Montana. A further analysis of the list shows that 12 of the 15 forms occur in the Vermejo formation of Colorado and New Mexico, 10 occur in the Mesaverde, or rocks of about this age, in Wyoming and elsewhere, and 6 species are common to both these areas. On the basis of this showing the conclusion that the Fruitland and Kirtland formations are of Montana age, seems justified.

R. W. S.

PHYTOPATHOLOGY.—*Mechanism of tumor growth in crown gall.* ERWIN F. SMITH. Journ. Agr. Research, **8**: 165–186, plates 4–65. 1917.

This paper, with its wealth of illustrations, records the results of a series of experiments testing the effects of various fluids and vapors on plants, undertaken for the purpose of shedding light on the mechanism of tumor growth in crown gall. As a result of these studies the author has come to look upon excessive cell proliferation as it occurs in plant neoplasms as due, not to the *direct* application of stimuli such as endotoxins and other by-products of the growth of the parasite within the host cells, but to their *indirect* action as the removers of inhibitions. Growth is the normal function of cells but under normal conditions is always inhibited beyond a certain point. *In the case of neoplasms we have an "inhibition remover that acts locally, disturbing tissue equilibriums within limited areas."* The author believes, furthermore, that this removal of growth inhibitions is not (or not wholly) due to a chemical action but partly at least to a physical one—viz., a locally increased osmotic pressure produced by the diffusion from the cells of various substances produced within them by the parasite as a result of its metabolism, together with the resultant counter movements of water and food supply, basing this belief upon the researches of Jacques Loeb in artificial parthenogenesis and fertilization, and on the results of his own experiments.

The substances produced by *Bacterium tumefaciens* in culture media containing dextrose, Witte's peptone, calcium carbonate, and water are ammonia, alcohol, acetic acid, formic acid, amines, aldehyde, and acetone. With several of these compounds, the author produced intumescences (both hypertrophic and hyperplasial) without the intervention of the organism itself. In addition to obtaining small tumors with crown-gall products (ammonia, dimenthylamine, and acetic acid) the author obtained overgrowths with a great variety of other substances; hence his conclusion that the response must be physical rather than chemical, i.e., due to removal of water from cells, which then divide.

The plants used were the castor-oil plant (*Ricinus communis*), tomato fruits, and cauliflower. The substances tested were injected hypodermically (Ricinus and tomato), placed in tiny open tubes inserted in the pith cavity (Ricinus, the wound being sealed with collodion or adhesive tape), or vaporized in a tight box containing 10.5 cubic feet air space in which the plants (cauliflower) were placed for a

few minutes. The substances tested were ammonia water, the various salts of ammonia, distilled water solutions of the acid component of these salts, distilled water, 10 per cent tannic acid, 10 per cent ethyl alcohol, 2 per cent sodium chlorid, 2 per cent sodium carbonate, 5 per cent sodium bicarbonate, 1/20 normal sodium hydroxid, 5 per cent ammonium bicarbonate, clear lime water, milk of lime (caustic), 1 to 10,000 mercuric chloride, 0.5 per cent carbolic acid, chloroform water, 1 to 1,000,000 copper sulphate water, 5 per cent grape sugar, 5 per cent cane sugar, and feeble alkaline vapors arising from dilute solutions of urea, ammonium carbonate, and the two ammonium phosphates, the mixed vapors of ethyl alcohol and acetic acid, and the vapor of secondary methylamine.

With all these substances, even distilled water, proliferations were obtained, but no killing of cells resulted except in the case of those coming into direct contact with too strong a solution. In Ricinus when ammonia was applied, the outgrowths were from the inner surface of the pith cavity, and occurred not only in the internode containing the chemical but in several to many others above and below.

Exclusive of the hyperplasia which appeared when vapor of acetic alcohol was used, one of the most striking effects obtained was the production of a stele within a stele in the pith of Ricinus by the injection of monobasic ammonium phosphate, and evidences of similar tendencies when ammonia was used. These facts together with the author's very successful production of teratoid tumors with *Bacterium tumefaciens* lead him to believe that fasciations and many similar phenomena are due to feeble infections by micro-organisms.

From these experiments the author concludes "that any soluble substance whatsoever, except a killing, a plasmolyzing, or an oxygen-absorbing substance, if continually liberated in excess locally in tissues not adapted to them would be able to induce tumor formation, and is convinced that had it been possible to apply these stimuli repeatedly, or better still, slowly and continually from within the cell—as does the parasite in crown gall—these striking proliferations would have developed into large irregular tumors, rupturing to the surface, i.e., into typical crowngalls. It is believed that this is the first time that galls have been produced with the chemical products of a gall-forming organism. The nature of the crown-gall products were determined for Doctor Smith by the Bureau of Chemistry of the United States Department of Agriculture from flask cultures set and controlled by him. F. H.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 784th meeting was held at the Cosmos Club, February 17, 1917, President BUCKINGHAM in the chair; 69 persons present. The minutes of the 783rd meeting were read in abstract and approved.

By invitation, Mr. H. BATEMAN presented an illustrated paper on *The nature of chemical forces.* Sir Joseph **J.** Thomson's idea[1] of regarding chemical bonds as symbols for Faraday tubes may be developed successfully by considering solutions of Maxwell's electromagnetic equations in which the electric and magnetic forces become infinite on moving singular curves.

We must first of all try to understand the nature of potential energy and so we shall commence by studying the properties of a type of radiant field with singular lines starting from the origin and running in both directions along the axis of z. The electric force E and the magnetic force H being specified by expressions of type

$$\begin{aligned} H_x + i E_x &= f(\alpha, \beta) \frac{\partial(\alpha, \beta)}{\partial(y, z)} \\ H_y + i E_y &= f(\alpha, \beta) \frac{\partial(\alpha, \beta)}{\partial(z, x)} \\ H_z + i E_z &= f(\alpha, \beta) \frac{\partial(\alpha, \beta)}{\partial(x, y)} \end{aligned} \qquad (1)$$

where $\alpha = t - \frac{r}{c}, \qquad \beta = \log \frac{x + iy}{r - z}, \qquad r^2 = x^2 + y^2 + z^2$

it is easy to see that there is a radial flow of energy outward from the origin. The origin O may be regarded as a source or singular point at which neutral particles are continually breaking up into oppositely charged fragments which travel along the axis of z in opposite directions with the velocity of light.

Two neighboring sources O and O' whose singular lines overlap can produce radiant fields which interfere with one another in such a way that in the total field the only singularities lie in the interval OO'. This can be seen very readily by differentiating the expressions (1)

[1] The corpuscular theory of matter. Constable, London (1907). Phil. Mag., May. 1914.

with respect to z after putting $f(\alpha\beta)=1$ and writing down the values of the Jacobians. In particular, if the strengths $f(\alpha\beta)$ of the two sources are constants which are equal in magnitude but different in sign, then as O and O' approach one another the total electromagnetic field is in the limit equivalent to the electrostatic field of a point charge, the magnitude of the charge being the limit of the product OO' and the strength of one of the sources. The potential energy of an electrostatic field can thus be supposed to arise from the individual and mutual energies of two interfering radiant fields whose singular lines overlap.

When the strengths of the two consecutive sources OO' are not constant and not equal in magnitude, we obtain a type of electric point charge with two singular lines attached to it, the charges on the two lines being generally variable and together equal and opposite to the variable charge associated with the singular point. The case in which the charge on each singular line is the same is of chief interest.

Interference, or a cancelling out of singularities, can also be obtained with two point charges of this general type even when they are at a finite distance apart, provided their singular lines overlap. There must also be a simple relation between the magnitudes of the two charges at associated times; this indicates that it may be possible to give a mathematical proof that the mean value of the electronic charge is the same for all electrons. It is thought that this phenomenon may have some relation to chemical saturation. The present theory may be extended to the case in which the sources or point charges are moving and the singular curves are not straight lines pointing in opposite directions but are moving and changing in shape. The appropriate solution of Maxwell's equations is again of the type (1) but α and β are now defined by the equations.

$$[x-\xi(\alpha)]^2+[y-\eta(\alpha)]^2+[z-\zeta(\alpha)]^2=c^2[t-\alpha]^2,\ \alpha<t,$$

$$\beta=\log\frac{l_1(\alpha)[x-\xi(\alpha)]+m_1(\alpha)[y-\eta(\alpha)]+n_1(\alpha)[z-\zeta(\alpha)]-cp_1(\alpha)(t-\alpha)}{l_0(\alpha)[x-\xi(\alpha)]+m_0(\alpha)[y-\eta(\alpha)]+n_0(\alpha)[z-\zeta(\alpha)]-c(t-\alpha)}$$

where $\xi(\tau)$, $\eta(\tau)$, $\zeta(\tau)$ are the coordinates of the source at time τ and $l_0(\alpha)$, $l_1(\alpha)$, $m_0(\alpha)$, $m_1(\alpha)$, $n_0(\alpha)$, $n_1(\alpha)$, $p_1(\alpha)$, are functions of α connected by the equations

$$l_1^2+m_1^2+n_1^2=p_1^2 \qquad l_1(\alpha)\,\xi(\alpha)+m_1(\alpha)\,\eta(\alpha)+n_1(\alpha)\,\zeta(\alpha)-cp_1(\alpha)=0$$

$$l_0^2+m_0^2+n_0^2=1 \qquad l_0l_1+m_0m_1+n_0n_1=1$$

This theory may be developed and applied to problems of atomic and molecular structure. Thomson's Faraday tubes are regarded as singular curves of generalized point charges and an arrow may be used to signify the direction of the flow of energy along a Faraday tube. The result of chief importance is that an *even* number of singular curves should be supposed to start from each point charge, the number being proportional to the mean value of the charge. It is suggested that the valency electrons in an atom are each doubly con-

nected by singular curves with the same element of the positive nucleus, while the other electrons in the atom have their singular curves connected with *different* elements of the positive nucleus and, like the electrons in the nucleus, help to keep the elements of the nucleus together. A change in valency may be associated with a change in the distribution of the singular curves or Faraday tubes. Thus, if the carbon atom contains six outer electrons two of which generally serve to bind together two nuclear elements each carrying three positive charges, it would be possible for the valency of carbon to change from four to two but not to any other value. Similarly, if the nucleus of the oxygen atom contains four α-particles and there are eight external electrons, the only possible valencies for oxygen will be four and two. On the other hand, if the nucleus of nitrogen is built up from two α-particles and an element carrying a triple charge and there are seven external electrons, then it is possible for such an atom of nitrogen to exhibit valencies of one, three, four, or even five. Diagrams were shown illustrating these changes and suggesting a way in which energy may be locked up in an atom, and, as energy is generally radiated when a singular curve changes its shape and direction, it is easy to imagine how some of this energy is radiated away during a rearrangement of the singular curves. It should be noticed that when the variation in shape of a singular curve is caused by an oscillation of an electric charge at one end the width of the waves which travel along the curve increases at a rate which is roughly equal to the maximum velocity of the source. Now if the motion of the source is of type $x = a \sin \omega t$, the maximum velocity is $a\omega$ while the maximum acceleration is $a\omega^2$, consequently, if ω is very large, i.e., if the waves are of high frequency, the velocity $a\omega$ may be negligibly small while the acceleration $a\omega^2$ is appreciable. Thus the intense radiation which travels along the singular curve may be concentrated and act like a quantum of energy.

The analogy with Thomson's model of the benzene ring also suggests that arrangements of electrons and positive nuclei in which energy flows in a cycle along the Faraday tubes are generally very stable. The suggested theories of gravitation and atomic structure are reserved for later publication.

The chair expressed to Mr. Bateman the thanks of the society for the interesting paper.

Mr. L. B. Loeb then gave a paper on *The electron theory of valence.* The fact that the 87 elements now known can combine to form only a limited number of the nearly infinite combinations mathematically possible, is explained through the fact that certain very definite laws of combination seem to exist. The manifestations of certain regularities shown in these laws give rise to a property that is defined as valency, a property which seems to show a periodic variation with the atomic weight of the element. The forces causing these combinations are generally accepted as being electrical in nature. The history of this electrical concept of valency was briefly discussed, giving the contributions of the various discoverers up to 1906. Since 1910 marked

contributions have been made to the knowledge of the nature of the atom. The discussion of the bearing of these contributions (i.e., the existence of the positive nucleus in the atom as indicated by scattering and deflections of alpha particles by atoms, and the atomic number with its significant bearing on the nuclear charge, as shown by the experiments on the X-ray spectra of the elements and the chemistry of the radio-elements) on the nature of the forces acting between atoms, furnished the main body of the paper. The experimental results indicate that the atom is entirely electrical in nature with a highly concentrated electrically positive nucleus surrounded by neutralising negative electrons. Of these electrons those in the outer layer are active in chemical unions. The possibility that the chemical forces are due to the magnetic fields of electrons revolving in the atoms was shown for several different reasons to be highly improbable. The mode of action of the electrons in binding the atoms was discussed. The electrons were shown to be capable of binding atoms in two ways in the two great classes of chemical compounds, i.e., the compounds showing strong electrolytic dissociation, such as NaCl, and the compounds showing no dissociation, such as the organic compounds and molecules like O_2 and N_2. In the former class there seems to be a complete transfer of the electron from one atom to the other, the atoms being held together by the opposite charges on them due to the transfer. In the latter class the electrons probably lie midway between the two atoms, acting then as actual binding links between them. The two classes of binding merge into one another in compounds of intermediate type. The type of binding taking place between two atoms is governed entirely by the nature of the atoms as given by the periodic system. The bearing of the atomic number and of the periodic system on valency were then discussed. It was shown that according to an idea of J. J. Thomson, which has recently been elaborated by Kosseo, the valency activities of the elements may be explained by the assumption that the atomic number represents the nuclear charge, and that every atom, even at the expense of losing or gaining outer electrons and thus becoming electrically charged, attempts to achieve the outer electronic configuration of the inert gas which *immediately precedes* or follows it. Since the inert gases are assumed to have eight electrons in their outer stable layer, one can explain many regularities found in the periodic table, e.g. why it is that the sum of the negative and positive valencies are equal to eight. To make the facts presented more concrete, the speaker, after having pointed out its weaknesses, adopted the Rutherford saturnian atom with revolving electrons as the most satisfactory model. With this model it was shown by diagrams how, on a theory recently suggested by Kossel, various kinds of molecules might be built up from such an atom.

Mr. F. R. Bichowsky then spoke on *Valence and color*. He pointed out that the characteristic feature of chemical union is that the valence electrons are held in equilibrium by forces of attraction and repulsion, both of which are presumably electrical and both of which are due

solely to the atom nucleus. This means that to explain chemical union one must assume either that Coulomb's law does not hold for the total (resultant) electrical force acting on an electron in a molecule, or else that the electron is such that other than purely electrostatic forces can act on it. At the point of equilibrium there is acting on a valence electron a restoring force which measures the stability of the electron arrangement, i.e., the "reactivity" of the compound. The magnitude of this restoring force, as determined by valence considerations and as checked by information furnished by the visible and ultra-violet absorption spectra, shows that an arrangement of eight and not six forms the most stable grouping of electrons around the positive nucleus. This can not be explained on any plane model of the atom, as this grouping requires lack of radial symmetry in the electron or nucleus. Saturnian atom models are inadmissible. Either they will radiate energy at the absolute zero (contradicting thermodynamics) or else they can not radiate at all. New physical assumptions are needed to construct a successful atom model, as one can not be deduced from the ordinary solutions of Maxwell's equations, these solutions being incompatible with the properties of the positive nucleus as well as with its very existence. The static model of the atom is preferable as, although it requires new and startling assumptions about the nature of the electron and the positive nucleus, these assumptions need not contradict the classical theories of physics.

Informal communications. Messrs. W. W. COBLENTZ and W. B. EMERSON presented to the Society a *Preliminary note on the selective reflection of tungsten.* The spectral radiation curves of incandescent tungsten filaments show peculiarities indicating the possibility of selective emission due to minima of reflection. The reflectivity curves of various metals, e.g. gold and copper, have in the visible spectrum indentations which give rise to strong selective emission in the incandescent metal. An examination of the spectral reflecting power curve of tungsten (in the form of plane highly polished mirrors) shows a small indentation at about 0.85 μ, which is greater than can be accounted for at present as being due to experimental errors. This depression in the reflectivity seems to be a property of the pure metal.

On account of the lateness of the hour, formal discussion was omitted.

DONALD H. SWEET, *Secretary.*

THE GEOLOGICAL SOCIETY OF WASHINGTON

The 313th meeting was held at the Cosmos Club, January 10, 1917.

INFORMAL COMMUNICATIONS

J. S. DILLER: *More evidence as to the high temperature of the late eruption of Lassen Peak.*

REGULAR PROGRAM

GEORGE OTIS SMITH: *Geology and public service.* (Published in The Scientific Monthly, February, 1917.)

J. WAYLAND VAUGHAN: *Significance of reef coral fauna at Carrizo Creek, Imperial County, California.* The paper gave a brief presentation of the zoogeographic relations of the fossil coral fauna of Carrizo Creek, showing the fauna to be related to the faunas of Pliocene and post-Pliocene age in Florida and the West Indies and on the eastern coast of Central America. The geologic history of the Tertiary coral faunas of the southeastern United States, the West Indies, and Central America was summarized. The conclusion was announced that subsequent to the uplift which separated the Atlantic and Pacific oceans at the close of Apalachicolan (upper Oligocene) time, there was during late Miocene or Pliocene time connection between the Atlantic and Pacific oceans, perhaps in the vicinity of the Isthmus of Tehuantepec, and that the Atlantic coral fauna extended up to the head of the Gulf of California. Factors not clearly understood excluded the Pacific fauna from this area.

Discussed by MENDENHALL, BARTSCH, and MACDONALD.

The 314th meeting was held at the Cosmos Club, January 24, 1917.

INFORMAL COMMUNICATIONS

A. L. DAY: *Cooling of a lava surface.* On the basis of computations by C. E. Van Orstrand the bottoms of cracks 3 to 5 feet deep in the surface of an extruded lava should be glowing hot several days after the extrusion. Observers at Lassen Peak a few days after the recent eruption did not report any glow in the cracks.

Discussion: SIDNEY PAIGE described and submitted a large specimen as evidence of plasticity of the recent lava at Lassen Peak.

REGULAR PROGRAM

ARTHUR J. COLLIER: *Age of the high gravels of the Northern Great Plains.* The area discussed extends along the south side of the international boundary, from Redstone, 30 miles west of the North Dakota line, to Boundary Plateau, a distance of 175 miles. From Boundary Plateau it extends northwest to include the Cypress Hills, where the Canadian Geological Survey, in the years 1883, 1884, and 1904, collected fossils from Bone Coulee, which are Oligocene and equivalent to the White River in age. The formation is composed of more or less cemented gravel, sand, clay, and marl characterized by water-worn quartzite pebbles from the Rocky Mountains. It rests on a plateau whose elevation above tide is 4800 feet at its west end and 3700 feet at its east end, near Bone Coulee.

During the past two field seasons the United States Geological Survey has made an investigation of the lignite resources of the region, in the course of which fragments of vertebrate remains were collected from 27 localities. These fragments, which came from wells, railroad cuts, badger holes, and natural exposures, have been submitted to Dr. J. W. Gidley, who reports that they can not be older than Miocene nor younger than Lower Pliocene. The formation called the Flaxville,

from which this material was collected, is composed of brownish to ash-gray silt, sand and gravel, and white marl from a few feet to 100 feet thick. It is generally noncoherent but locally cemented with calcite and forms prominent outcrops, often marked by cross-bedding. The gravel is characterized, like that of the Cypress Hills, by material from the Rocky Mountains. It is found on four extensive plateaus ranging in elevation from 2700 feet, south of Redstone, to 3200 feet in the west side of Boundary Plateau.

Below the Flaxville level there are extensive areas, varying in elevation from 2500 to 2700 feet, in which the bedrock is generally near the surface. Several exposures of quartzite gravel interstratified with yellowish silt lie at an elevation of 2500 feet a few miles north of Milk River. A single fossil tooth collected from the gravel was submitted to Dr. Gidley, who pronounces it either a recent or Pleistocene horse. The erosion of these large areas is thought to have been accomplished in early Pleistocene time. Since early Pleistocene the streams have eroded their valleys, but this erosion was clearly before the last great glacial advance, and the valley floors are therefore regarded as having been formed during late Pleistocene and Recent times.

Discussion: W. C. ALDEN said the gravels are well rounded, and that erosion to a depth of at last 1000 feet occurred between the time of an older glaciation and the Wisconsin. J. W. GIDLEY suggested that the fossils in the gravels were derived from older formations.

J. C. HOSTETTER: *The linear force of growing crystals.* The literature on this subject shows that a loaded crystal will grow against a load and lift it. This was first demonstrated by Becker and Day in 1905 and, although their conclusions were attacked by Bruhns and Mecklenburg in 1913, the recent papers of Taber and of Becker and Day show definitely that the linear force exerted by growing crystals may develop large pressures and hence must be considered a factor in vein formation. In these latter papers the explanation given for Bruhns and Mecklenburg's failure to observe an elevation of a load placed on a crystal when an unloaded crystal was growing in the same solution was that the solubility of the loaded crystal was greatly increased by the pressure acting on it, and therefore the degree of supersaturation sufficient for the growth of the unloaded crystal was insufficient to cause growth of the loaded crystal.

We should here distinguish between pressure acting equally on both phases of a system—uniform pressure—and pressure which acts in excess on the solid—non-uniform pressure. The effects are quite different in the two cases, as has been pointed out by Johnston and Adams. The change in solubility produced by uniform pressure is very small as compared to the effect of temperature—1000 atmospheres so applied being equivalent to about 14°. Preliminary experiments on the effect of non-uniform pressure on solubility under carefully controlled conditions indicate that the effect of pressure acting on the solid but not on the liquid is much smaller than that brought about by the same pressure acting uniformly on solid and liquid.

Experiments with loaded crystals of potassium alum show that these crystals will lift their loads during growth, even if unloaded crystals are present, as long as the conditions of growth are controlled. The essential point to be considered is that the measure of lifting is the depth of whatever "cavities" may form on the upper or lower surfaces of the loaded crystal. With large crystals these height increments are very small compared to the growth on the top surface of an unloaded crystal and hence were probably overlooked in comparison with the latter. Other factors entering into the lifting effect produced are the relation of load to the crystallographic direction, and the habit of the crystal. The mechanism by which this lifting takes place is not at present known. Taber's view is that the lifting is caused by the expansion which takes place when the solid separates from the film of solution which is assumed to be always under the supporting edge of the crystal. Unfortunately, the experimental difficulties involved in testing this conclusion have not been overcome, so that the matter is unsettled. Another possible explanation is that the lifting effect is an expression of those forces responsible for crystal development. The experimental results obtained with crystals with painted surfaces indicate this explanation.

Discussion: E. T. WHERRY described examples of fibrous crystals produced by crystal interference.

J. W. GIDLEY: *The origin of the mammals.* (No abstract.)

Discussed by R. S. BASSLER.

The 315th meeting was held at the Cosmos Club, February 14, 1917.

INFORMAL COMMUNICATIONS

H. E. MERWIN: *Diffusion and crystallization of metallic copper in crystalline sulphides.* After cooling from a molten state in a vacuum copper-iron sulphides may contain an excess of copper which slowly diffuses and crystallizes at ordinary temperatures. The growing crystals of copper open cracks in the solid mass in which they form.

REGULAR PROGRAM

D. F. HEWETT: *The origin of bentonite and the geologic range of related materials in Bighorn basin, Wyoming.* Bentonite is a drab and cream colored bedded clay which until recently has been recognized only in the upper part of the Benton formation in Colorado, Wyoming, and Montana. Work on the west side of Bighorn Basin has shown that bentonite and clays closely resembling it occur at intervals from the base of the Benton formation of the Colorado group to the top of the Meeteetse formation or upper part of the Montana group. The beds occur, therefore, in a stratigraphic range of about 5500 feet in Bighorn Basin. A clay that closely resembles bentonite is also interbedded with tuffaceous rocks in an upper Eocene formation near Owl Creek.

In order to determine the mineral constituents of bentonite, six specimens were sized by the Bureau of Soils, and the proportions of each of

the more abundant minerals were determined in each size by immersion in oils of known index of refraction. In order that a comparison with bentonite might be made, seventeen specimens of sediment from associated beds were also sized.

Bentonite contains two classes of material. On the one hand, the sands and silt, which include grains that range from 0.005 to 1.0 mm. in diameter, are largely plagioclase (andesine), orthoclase, and biotite, with accessory quartz, glass, apatite, zircon, and agate. The grains of plagioclase and orthoclase are highly angular and are uniformly fresh. Most of the grains of quartz are also angular, but a few are well rounded, whereas the grains of apatite and zircon are fresh terminated crystals. On the other hand, the clay, which includes all grains less than 0.005 mm., shows by analysis water, silica, and alumina. The molecular ratio of silica to alumina is about 9 to 1, and therefore much higher than that in any of the common hydrous silicates of alumina. The dried powder is birefracting (biaxial negative) and the average refringence of different specimens ranges from 1.52 to 1.59. After the clay has been immersed in water, however, it is isotropic and therefore amorphous. This clay forms 73 to 86 per cent of the beds of pure bentonite, whereas the sands and silts make up the remainder. In the beds of impure bentonite however, the proportion of clay is lower and ranges from 54 to 61 per cent. One of the peculiar properties of the clay is its tendency to swell to six or eight times the original volume when immersed in water.

The clays, shales, and sandstones of the adjacent sediments which have been examined, are common types of quartzose sediments. Subangular grains of quartz and chert make up a large part of the coarsest sizes of most of the sediments, but a little orthoclase, biotite, plagioclase, and chlorite are commonly present. Quartz also forms an appreciable part of the finest silt and clay portions, but the birefracting clay of bentonite was not noted in any of the clay portions of these sediments.

In contrast with adjacent sediments, therefore, bentonite contains little if any quartz, but fresh plagioclase, orthoclase, and biotite predominate, and glass is locally present. The comparison of the mineral constituents of bentonite with volcanic ash from several localities, shows that whereas the variety and proportions of the minerals are strikingly similar, the proportion of glass grains in volcanic ash is represented in bentonite by the highly siliceous clay just described. The resemblance in mineralogy and chemical composition of the two classes of materials warrants the conclusion that bentonite is volcanic ash in which the glass has been hydrated and has lost most of its constituents except silica and alumina. An inquiry into the stratigraphic relations of the beds of bentonite appears to show that this alteration must have taken place before the ash was laid down. In the case of the Eocene clays, which are flood-plain deposits, the decomposition took place after deposition.

The geologic range of bentonite and the areas within which it is known to exist show that volcanic products probably make up a larger part of the Cretaceous sediments of the region than has been recognized heretofore. Beds of bentonite are present in the Bighorn Basin section, 3000 feet below the horizon equivalent to the base of the Livingstone formation in Montana, which is largely made up of volcanic materials. The source of these volcanic products cannot be determined, but probably is to be found in the region west of eastern Idaho and Utah.

Discussion: C. J. HARES spoke of the distribution and geologic relationships of bentonite. E. T. WHERRY outlined a process by which bentonite is made into a commercially important product for the softening of water. The bentonite is heated and treated with an alkali salt. The resulting material will exchange its alkali for the lime of hard water. F. J. KATZ called attention to the unusual process of alteration involved in the explanation of the origin of bentonite as presented.

FRANK J. KATZ: *Stratigraphy in southwest Maine and southeast New Hampshire.* The following sedimentary formations and groups have been established for the coastal region between the head of Casco Bay, Maine, and southern New Hampshire:

The Berwick gneiss, consisting of highly metamorphosed and recrystallized graywacke, quartzite, and thin micaceous beds, which are developed in a belt 1 to 10 or more miles wide extending southwest from Falmouth and Gorham, Maine, to and beyond Lee, New Hampshire. The formation is of undetermined but probably pre-Cambrian age.

An Algonkian (?) crystalline complex of quartzite, rhyolite, hornblende schist, and graywacke gneisses in Kittery, Maine, and Portsmouth, Newcastle, Rye, and North Hampton, New Hampshire.

The Carboniferous (Pennsylvanian?) Kittery quartzite, a thick formation containing thin-bedded quartzites and argillites in a belt about 10 miles wide along the coast from Saco, Maine, to Portsmouth, New Hampshire, and continuing thence inland in a southwesterly direction to the Merrimack River, where it forms part of the Merrimack quartzite of Massachusetts.

The Eliot slate, the rocks of the Casco Bay group, and the rocks of the Rochester, New Hampshire basin, which are developed in three separate areas but are approximately equivalent and conformably above the Kittery quartzite. Of these the Eliot slate, in Eliot, Maine, and Dover, New Hampshire, and extending thence southwest in two belts, consists of gray sericitic and silicious slates, argillo-quartzitic schists, calcareous beds, and carbonaceous phyllites. The Casco Bay group occupying an area about 12 miles wide and 30 miles long extending along the coast from Saco, Maine, to the head of Casco Bay, consists of the Cape Elizabeth formation of graywacke schists, gray gritty slates, sericite phyllites, and calcareous carbonaceous laminae; the Spring Point greenstone; the Diamond Island slate, a graphitic and pyritiferous quartz slate; the Scarboro phyllite, a carbonaceous sericite phyllite; the Spurwink limestone; the Jewell phyllite; and the Mackworth slate. The

rocks of the Rochester, New Hampshire, basin include the Gonic formation, in a belt 2 to 4 miles wide running from Sanford, Maine, to Barrington, New Hampshire, made up of graywacke schists, mica schists, and garnet-staurolite phyllites; the Rindgemere formation, occupying a broad area in Rochester, New Hampshire, and Acton and Lebanon, Maine, and lying northwest of the Gonic formation, is composed of quartzite, slates, and mica schists, but predominantly of carbonaceous sericite phyllites which contain chiastolite; and the Towow formation, in the town of Lebanon, Maine, and surrounded by the Rindgemere formation, consists of graphitic and pyritiferous quartz slates and carbonaceous sericite phyllite.

The igneous rocks are grouped as: (1) pre-Carboniferous granites, pegmatites, and diorites; (2) late Carboniferous or early post-Carboniferous schistose granodiorites; (3) post-Carboniferous biotite and muscovite-biotite granites, pegmatites, and hornblende diorites; and (4) probably Triassic trap dikes.

The distribution of these rocks was shown on maps on which the rocks of southwestern Maine and southeastern New Hampshire were systematically arranged for the first time. Earlier efforts had resulted only in conflicting petrographic categories without stratigraphic meaning. It is now known that instead of being pre-Cambrian or early Paleozoic rocks, as all had been supposed to be, more than half of the rocks, areally considered, are Carboniferous (Pennsylvanian?) or younger. The other rocks are in part certainly, and the remainder probably, pre-Cambrian.

Discussion: BROOKS, LA FORGE, PAIGE, LOUGHLIN, AMI, and WHITE called attention to the difficulties in establishing age relations, owing especially to the lack of fossils and to the disturbed and metamorphosed conditions of the rocks. The fact that a very definite trend in the structures had been established was emphasized as establishing relationships with the rocks of eastern Massachusetts.

H. E. MERWIN, *Secretary.*

THE BOTANICAL SOCIETY OF WASHINGTON

The 118th regular meeting of the Society was held in the Assembly Hall of the Cosmos Club, at 8 p.m., February 6, 1917; forty-four members and fourteen guests present.

Dr. B. T. GALLOWAY, Mr. CHAS. F. DEERING, and Prof. W. D. CROCKER were elected to membership.

The program of the evening was *The relation of plant succession to forestry and grazing.*

Mr. C. G. BATES stated that foresters were first to apply in a practical way the knowledge of plant succession, and were in a sense the progenitors of this type of ecological science. The natural regeneration of forest stands in each of the climax formations of the Rocky Mountain region was shown to involve succession, there being in nearly all cases temporary control by a sub-climax following the disturb-

ance due to cutting. In practical forest management each formation was shown to present distinct problems in which the kind or degree of cutting is the controlling factor. The correct solution of these problems involves an intimate knowledge of the range of conditions under which the climax type can succeed. Direct seeding of forest trees on ground not recently occupied by the climax forest has usually resulted in failure.

Dr. J. V. HOFFMAN called attention to the successions in the forests of Washington and Oregon. Two types of succession were distinguished: (1) A type in which the production, distribution, germination of seed, and the establishment of seedlings are important. This type is dependent therefore on the presence of seed trees and progresses into an unoccupied area only 150 to 300 feet during each generation. The resulting forest is composed of trees of uneven age. (2) A type dependent primarily on the viability of seed and in no way dependent on remaining seed trees. The seeds produced by the old stand retain their viability when the forest is destroyed and germinate to form a new forest of the same type and of even-aged trees.

Mr. A. W. SAMPSON discussed succession as a factor in the management of the range lands of the Forest Service. Succession, or the alternation in the vegetative personnel of an area was found to occur whenever the natural conditions of the environment had been appreciably changed. Where the vegetative cover had been disturbed more or less seriously on pasture and range lands, and the disturbing factors subsequently eliminated or their intensity decreased, the vegetation, through successive invasions, gradually became more like the original.

In the administration of the range on National Forests with a view of maintaining a maximum forage cover, a clear recognition of the successional stages represented by the more conspicuous species is important. Certain species occur early and others late in the succession leading to the development of the climax or ultimate type. The conspicuous appearance of species which occur early and which are usually of little or no value for grazing, shows clearly that the pasture is being improperly used and that a change must be made in the management if the remaining desirable species are to be preserved. Studies of the growth requirements, the life cycles of the more important species, and the successional stages make possible the initiation of systems of management favorable to the invasion and succession of the species desired.

Mr. E. O. WOOTON discussed the succession due to protection of a badly overgrazed area on the foothill slopes and adjacent sloping plains of the northwest side of the Santa Rita Mountains in southern Arizona. Quadrat collections were made at various stations at intervals during a period of eleven years. From this data the following successional stages were recognized: (1) Small weedy annuals in spring and annual grasses in summer and fall. (2) Short-lived perennial grasses. (3) Long-lived perennial grasses and a few species of perennial herbs

and very low undershrubs. Succession was most rapid on the upper slopes and the annual and perennial grasses gradually moved down the slopes into drier situations. Fire is the principal factor in preventing shrubs from replacing the grasses.

In the informal discussion Mr. G. A. PEARSON discussed the reseeding of yellow pine areas; Mr. J. T. JARDINE, how to maintain a most productive subclimax type of vegetation for sheep pasturage; Dr. DAVID GRIFFITHS, the effect of fires on the maintenance of the grass stage in Arizona; and Dr. H. L. SHANTZ, the importance of a knowledge of succession in the interpretation of the results of range management.

H. L. SHANTZ, *Corresponding Secretary.*

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 566th meeting of the Society was held in the Assembly Hall of the Cosmos Club Saturday, February 24, 1917; called to order by President Hay at 8 p.m.; 50 persons in attendance.

Under the heading book notices, brief notes, exhibition of specimens, etc., M. W. LYON, JR., called attention to the latest edition of the International Rules of Zoological Nomenclature containing a summary of the opinions that have been rendered by the International Commission, compiled by Mr. John Smallwood of Washington.

Dr. R. W. SHUFELDT communicated a short paper entitled "Notes on the Trunk-fishes" and exhibited a specimen of *Lactophrys tricornis.*

Dr. L. O. HOWARD commented on the parent tree of an unusually fine variety of oranges and the extraordinary care taken of it by the owner during the recent cold weather in Florida.

Mr. WM. PALMER also commented on the effects of the recent "freeze" in Florida.

The regular program consisted of three communications as follows:

T. S. PALMER: *A pioneer naturalist in southern Florida.—Extracts from the diary of Titian R. Peale, 1825.* Dr. Palmer gave a detailed account of Peale's collecting trip in Florida in 1825 made for the purpose of securing birds for Prince Louis Bonaparte and mentioned and exhibited the species of birds discovered by Peale as new to science or new to the United States. He read extracts from Peale's diary and called attention to the other scientific expeditions of which Peale was a member, giving many interesting facts of his long life.

A. L. QUAINTANCE: *Some notes on the Aleyrodidae.* (No abstract.)

EMERSON STRINGHAM (introduced by R. E. Coker): *The shad and its relatives in the Mississippi river.*

Mr. Stringham said that herring-like fishes found in the Mississippi river possess more economic significance than formerly recognized. The two mooneyes (*Hiodon*) have flesh of excellent quality, but they are not sufficiently abundant to be of great importance. They eat principally insects, and feed both summer and winter, day and night, and they deposit their eggs as soon as the water temperature begins to rise in spring. The gizzard shad (*Dorosoma*) which serves as food

for other fishes is less abundant in the Mississippi proper than in slough and lakes. The river herring (*Pomolobus chrysochloris*), known as the host of a mussel of great value, feeds on insects when they are abundant, and on fishes at other times. It breeds early in summer. Fears are entertained that the fish and mussel may be excluded from the upper river by a dam at Keokuk, Iowa. The Ohio shad (*Alosa ohiensis*) seems clearly distinct from the Atlantic shad, but is sufficiently similar to be equally good food, though smaller. On the Mississippi this valuable resource is not utilized. The habits of the fish are similar to those of the Atlantic species, but it has not yet been proved to be anadromous.

M. W. LYON, JR., *Recording Secretary.*

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

The 508th meeting of the Society was held at the New National Museum on March 6. This meeting was devoted to a general discussion, the subject being *Problems connected with the distribution of the aboriginal population of America.*

Dr. JOHN R. SWANTON introduced the discussion by stating that the subject divided itself into a consideration of the distribution of aboriginal population in America quantitatively and qualitatively. "Populations," said Dr. Swanton, "may be classified qualitatively according to their physical characteristics, languages, cultural features, social organization, and so on. Archeology has a bearing on all these." He gave as one of the principal problems to be considered the bearing of the data of each class on the generally admitted Asiatic origin of the American Indians and their diffusion from the northwest.

Dr. ALEŠ HRDLIČKA, speaking from the standpoint of physical anthropology, stated that the distribution of different physical types on the American continent has always been in this country one of the main problems of his branch of science. Morton, the father of American anthropology, classified the American Indians in two types: (1) The Toltec, or refined type, which included the Toltecs of Mexico, the Maya, and the mound-builders of the Ohio valley; (2) The Barbarian, which included all the less civilized, semi-nomadic tribes.

This classification, although imperfect, was shown in the course of time to have a good foundation. Roughly speaking we recognize today two great sub-types of the American aborigines which correspond in the main to Morton's groups. The "Toltec" strain shows an irregular but wide distribution over both Americas. Its main areas are portions of the northwest coast, a part of the Pueblo region, a large part of the more southern territory of the "mound-builders," all Yucatan, southern Mexico, Central America, the Antilles, the western region of northern South America, and the coast of Peru, with as yet undetermined areas in Brazil, and traces even farther south. The type is principally marked by brachycephaly. The second Morton group corresponds to the American dolichocephalic population which ex-

tends over vast areas from Labrador and Canada to Tierra del Fuego. Which of these two types is the older on the Continent has not yet been determined. The answer will doubtless differ in different localities. Besides these two, which may be called fundamental physical types of the American population, we now recognize a third group which, though closely related to the first or "Toltec," seems of much more recent introduction and development; this is the Athapascan. A fourth type, also of fairly recent introduction, is the Eskimo. Outside these four strains, all of which are related and proceed probably from one ancient stratum, we have discovered as yet in America no trace of any other Pre-Columbian population.

Dr. TRUMAN MICHELSON, speaking on the linguistics of the Indians, said, "There is no single type of language, no fundamental structure that is the same in all linguistic stocks, though we find resemblances among them." The speaker stated that resemblances occur between the languages of northeastern Asia and those of certain North American Indians. "An important problem in linguistics," said Dr. Michelson, "is to determine whether resemblances between languages are genetic or borrowed." The distribution of linguistic stocks was indicated on maps.

Prof. WILLIAM H. HOLMES spoke briefly of the probable origin of the human race in southern Asia and the gradual spread from this cradle over wide areas through increase in numbers and intelligence. In passing northward the culture would be gradually modified and on reaching the Arctic it would be reduced to the hunter-fisher state exclusively known throughout the Arctic. In passing to America by the Behring Route migrating groups would carry with them only this single culture stage, but advancing southward changes would take place according to environment. Culture would take on one phase in the Great Plains region, another in the Mississippi Valley, still another in Mexico, and so on; and there would follow interchanges of culture elements between peoples and areas without end. We thus explain the complex conditions and great diversity of the Columbian period.

Dr. J. WALTER FEWKES stated that the two great forces which have influenced the distribution of population in North and South America are (1) geographic, the course of migration being somewhat determined by the mountain ranges and rivers, and (2) the food supply, which depended on the climate. Dr. Fewkes called attention to the fact that language does not represent the cultural distribution of a people. Languages shrink and change, but archeology often represents culture in its highest manifestation and affords a permanent basis of study. Thus archeology indicates that two types of people once lived in the southwest. There were two foci of distribution, one in the San Juan valley and the other in the Gila valley. The food quest broadened the outlines of these groups and at the point of juncture there arose a mixed type which we now find along the Little Colorado, while in the original places the culture has entirely disappeared. Dr. Fewkes

spoke of the large and important cultural groups found in the West Indies where the Carib stock was preceded by another stock, the Arawak, both originating in South America. In the West Indes the root of the yuca bears the same relation to the food problem of the people that the corn bears in the southwest.

Dr. WALTER HOUGH said that at the Discovery the tribes of America were identified with the environments in which they had settled and since that time only migrations of a minor character have taken place. The causes of extensive migration were thus conjectural but depended on basic facts of food, transportation, and artificial fire-making.

Mr. FRANCIS LA FLESCHE stated that the ancient rites of the Siouan stock show that the migrations of the people were influenced by the search for food. The first animal mentioned in these rites is the elk, succeeded by the deer, and later by the buffalo, at which period the mention of corn appears for the first time.

FRANCES DENSMORE, *Secretary.*